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WALKING IN OPEN SPACE

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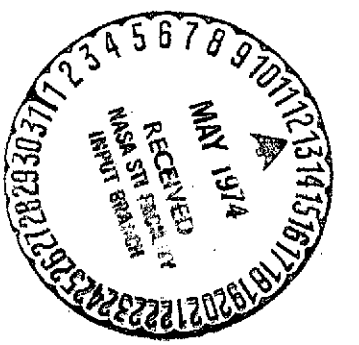

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WALKING IN OPEN SPACE

Colonel G. Titov*

COSMONAUTS ANSWER READERS' QUESTIONS

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With the development of cosmonautics, the range of scientific and technical problems it has solved is growing more and more. Even now, in near-Earth space, a number of space systems are constantly functioning: communications systems, meteorological systems, and navigation systems. With time, their number will increase and the systems will become more complex. There is also an increase in the number of experiments aboard long-term orbital stations. All this requires increasing participation of cosmonauts in accomplishing various operations in open space.

What sort of work is this? It should include assembly, maintenance and repair of different equipment of spacecraft and space stations, transporting cargoes and changing the crews of orbital stations, rescuing cosmonauts and spacecraft, inspecting the latter to evaluate their condition, removing information from spacecraft, and, in the future, assembling large orbital stations as well.

As is known, the Soviet cosmonaut A. Leonov was the first to enter open space. This took place on 18 March 1965. Since that time, both Soviet and American cosmonauts have carried out different experiments outside the spacecraft on many occasions.

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* Pilot-Cosmonaut, USSR, Hero of the Soviet Union.
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During the flight of the "Skylab" station, for example, the American astronauts entered space several times to replace film cassettes in the astronomical instruments. They had to carry out repair operations on two occasions — they had to shield a portion of the station from solar overheating with specially manufactured panels to replace the anti-meteorite screen which was torn away during the first part of the flight. They also inspected the broken down engine of the attitude-control system of the "Apollo" transport spacecraft, which was docked with the station.

According to the report of the American astronauts, it was not easy to do all this: certain operations which had seemed easy up until then required a great deal of effort and time. The movement of the supply hose through which the astronauts received their oxygen for breathing and maintained communications among themselves was constrained and the supply hose often spun and fouled.

Flight experience indicates that for accomplishing these operations in space one needs a combination of special equipment and devices for the work and movement of cosmonauts.

The simplest equipment supporting the egress of the cosmonaut and his return to the spacecraft is a line system which flexibly links the cosmonaut with the spacecraft. As investigations show, however, the line system only permits the cosmonaut to go a relatively short distance from the spacecraft, a distance on the order of 10 meters. With a further increase in distance, undesirable rotation of the spacecraft relative to its center of mass can appear, as the result of which the line will wind about the spacecraft and this, in its turn, will lead to an increase in the rate of approach of the cosmonaut to the spacecraft and to extreme tension on the line. Of course, one could eliminate line-winding by actively controlling the spatial attitude of the spacecraft by

creating reactive thrust at both ends of the line, by employing an additional "anchor" mass, or by other means. But it is obvious that such a system does not make it possible for the cosmonaut to work at a significant distance from the spacecraft.

For carrying out work in open space, when it is necessary for the cosmonaut to move from one space object to another, he should have special equipment at his disposal.

Up to now, various devices of this nature have been created or are being created. There are already devices of the hand, foot, and back-pack type. There are designs for specially equipped platforms.

The hand device, which in the simplest form is a jet nozzle or a system consisting of several nozzles, mounted in a handle, creates a small thrust and enables the cosmonaut to move about in /35
space in the immediate vicinity of the spacecraft. The fuel mixture (for example, hydrazine and water) is stored in a tank kept in the handle or in a backpack worn on the cosmonaut's back.

With all of its simplicity, however, such a system has significant shortcomings: small supplies of the working fuel, and, consequently, limited radius of action; the hands of the cosmonaut are also occupied, reducing body stability.

The foot device for moving in space differs from the hand device in that the jet nozzles are mounted on the cosmonaut's boots at a certain angle to the plane of the soles of the feet. The hands of the cosmonaut are free. However, the tests of this device, carried out aboard the "Skylab" orbital station, showed that its use is practically impossible due to difficulty in controlling the spatial attitude of the body.

The back pack device and the container type are designed for movement of the cosmonaut at significantly long distances from the spacecraft. The back pack device can be quite large (weighing over 100 kg) and consists of chest and shoulder packs. In these packs, besides the elements of the life support system, there are cylinders containing fuel, a portion of the motor, the gyroscopic control system, telemetric and radio apparatus. The fuel expenditure sensors, connected to light and sound signalling devices, warn the cosmonaut in time if the fuel reserve or oxygen for breathing is about to run out. Such a device, which has several groups of jet nozzles, can support not only movement in space, but can also stabilize the person working in space relative to the of pitch, yaw and roll axis. It can be controlled both by the cosmonaut himself and by other crew members remaining aboard the spacecraft.

Inasmuch as we have touched on remote control of devices for cosmonaut mobility in open space, it is obviously necessary to say a few words about unmanned devices of this type. Specialists consider that unmanned devices (these include remote controlled manipulators, controlled by an operator from the Earth or from a space station) will be primarily employed in carrying out operations which entail risk of the cosmonaut's safety. These are operations in assembling and servicing nuclear energy installations and engines. In carrying out operations dangerous for man, they provide a degree of flexibility not attainable by fully automatic systems.

One of the most important operations in open space is conducting rescue operations. Here one might require a device which can be remotely controlled from a spacecraft, for example, by the aid of television or a radar system.

Imagine that a person who has gone out into open space has lost the capacity to control the device for movement. In this case,

those aboard the spacecraft can take remote control and return both the device and the cosmonaut to the spacecraft.

If there are any technical malfunctions during work in open space, the crew members remaining aboard the base-spacecraft can send their comrade a device with equipment for making repairs, or with spare parts.

Specially equipped platforms could become even more complex apparatus designed for various orbital operations.

S.P. Korolev termed such apparatus space "taxis". Sergey Pavlovich spoke of the possibility of using them for transferring people from spacecraft to spacecraft. Such a platform will serve to move cosmonauts hundreds of kilometers from their base spacecraft. It could have a hermetically sealed cabin. It is expedient to equip it with two hatches: one for entering open space, the other for transferring to spacecraft with which the platform is docked. Such apparatus can also have remotely controlled clamps, enabling one to lock them in any necessary position relative to the object being serviced.

Enabling cosmonauts to walk in open space and supporting their activity require that specialists take into account many characteristics when developing the necessary technology. We shall consider only the principles of motion of the cosmonaut relative to the spacecraft after he has left it and the conditions of returning to the spacecraft. Having left the spacecraft, he himself becomes an artificial satellite of the Earth and becomes governed by the laws of celestial mechanics.

In principle, the cosmonaut equipped with a device for movement can travel in any direction from the spacecraft. Depending on the direction away from the spacecraft, different cases of movement will develop.

For example, if he moves away from the spacecraft in the direction of the spacecraft flight, then at first he outruns the spacecraft and then rises above it. Why does this happen? Because any increase in orbital velocity, even a slight one, raises the flight altitude. Then the cosmonaut begins to separate from the spacecraft, always remaining above it. Here the large period of rotation already has its effect. Subsequently, the character of movement will be repeated and the cosmonaut will become more and more separated from the spacecraft.

When the cosmonaut moves away in a direction counter to the direction of flight, he will move below the spacecraft, and it outdistances him.

We have only indicated two of the cosmonaut's directions of movement. During motion in other directions, the resulting trajectory will be more complex.

These characteristics of the cosmonaut motion must be taken into account, for otherwise it would be difficult for him to return to the spacecraft or to reach another spacecraft without using other, additional facilities. Moreover, they should also be taken into account in order to expend the fuel economically.

Depending upon their purpose, devices for movement will differ in their design, engine power, and fuel supply. In connection with this, an estimate of energetic expenditures for movement in open space also poses a complex problem.

The expenditure of fuel for cosmonaut movement between two space objects with a return to the base spacecraft will depend on a large number of factors which obviously include the masses of the device and the cosmonaut, the duration of the operation and its separate stages, the parameters of the relative motion of the two

space objects, and the methods of controlling motion which are employed in open space. In the latter instance, a role will be played by the cosmonaut's level of training to accomplish the manual control operations of the movement device.

Taking all these factors fully into account can apparantly be done only as the result of experimentally developing specific movement devices.

Hence, in creating devices enabling man to walk in open space, there are as yet many unsolved problems. The possibilities of their use and the requirements which they must satisfy have not yet been fully investigated. However, the basic requirement can be formulated quite clearly — maximum reliability. The cosmonauts who must use such devices should be satisfied that they will not break down in working or critical situations.

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16. Abstract

A description is given of the operations involved when walking in space. These include assembly, maintenance and repair of different spacecraft equipment, changing crews of orbital stations, rescuing cosmonauts and spacecraft, and others.

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